Thermal Infrared Planetary Science Imager User Manual

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This guide has everything you need to get started using TIPSI via the TISPI_Controller graphical user interface. If you have any questions not answered by this manual or just want to suggest things to change, please email tipsi@nau.edu.

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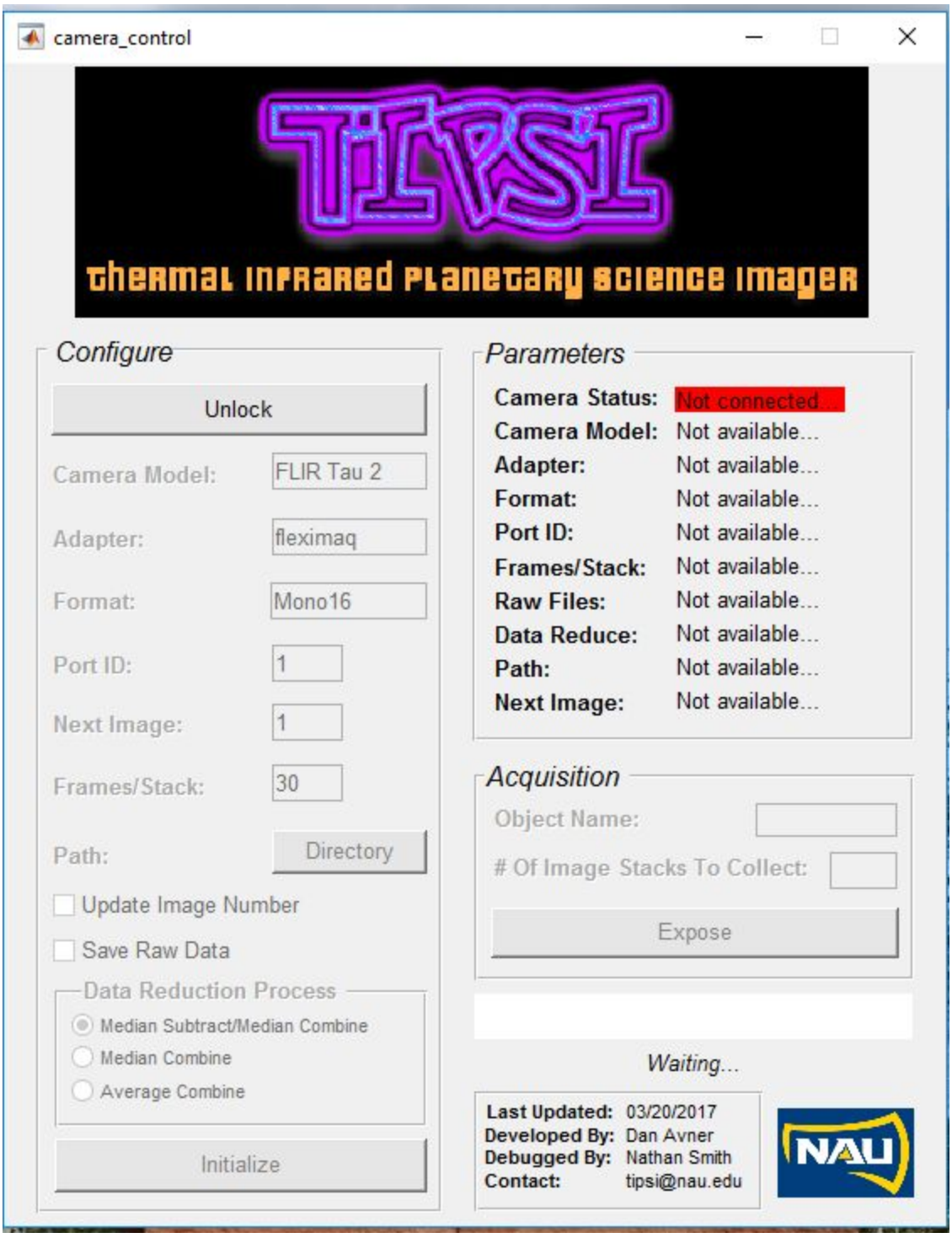
1 General Information



1.1 Introducing TIPSI

The Thermal Infrared Planetary Science Imager (TIPSI) is a new way to perform infrared astronomy. Using the same Forward Looking InfraRed (FLIR) technology used in military thermal imaging cameras, TIPSI is, in comparison with conventional infrared astronomical sensors, simpler, faster, and cheaper. Despite operating in the 8-12 μm range, TIPSI is uncooled, requiring no cryostat, liquid coolant, or complex plumbing. This drastically reduces the complexity and cost of both development and operation. We hope this new technique will bring down the barriers of entry for smaller institutions to try out infrared astronomy for themselves.

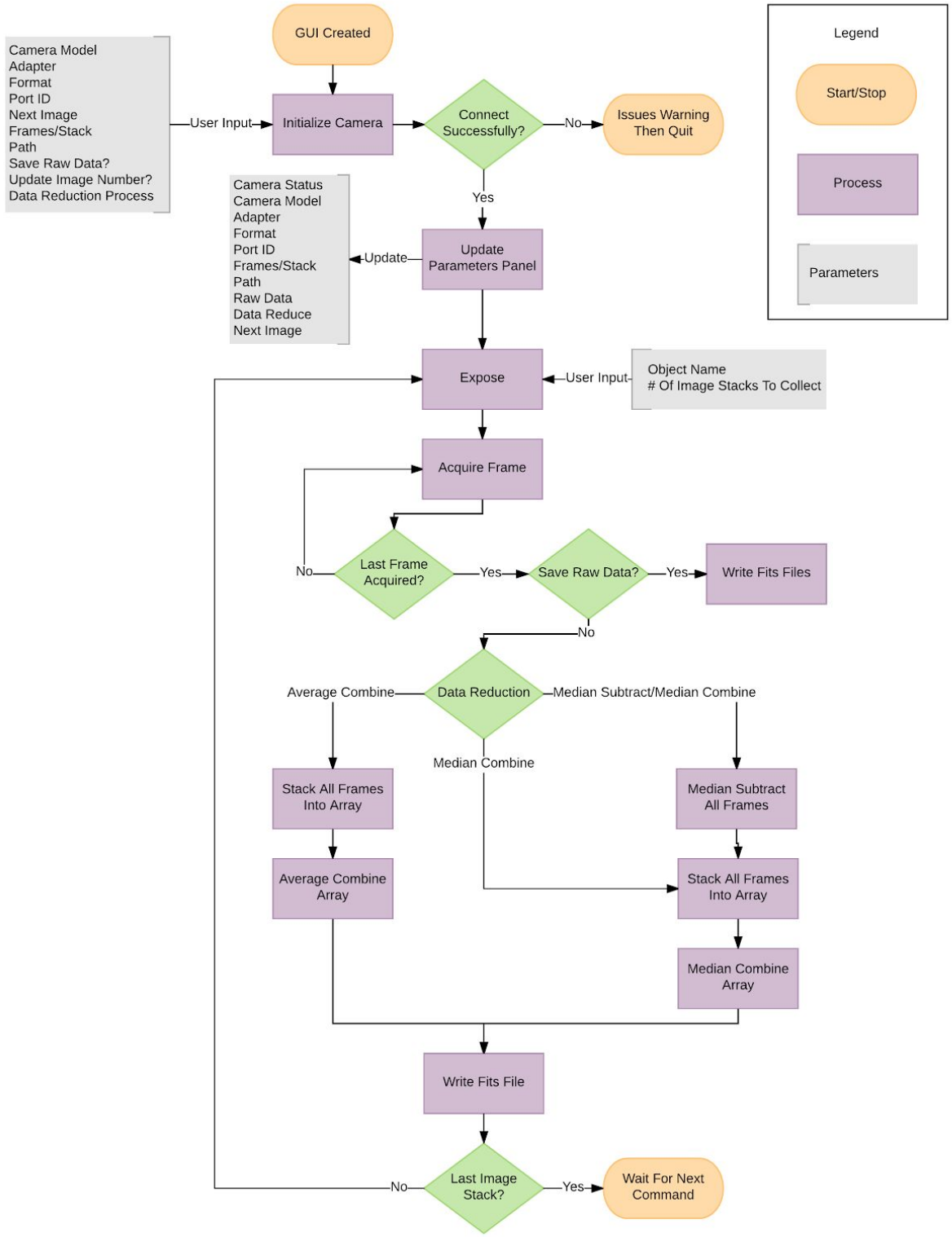
1.2 TIPSI GUI

In keeping with our design philosophy of faster, better, cheaper, TIPSI is operated by means of a simple Graphical User Interface (GUI). Behind the scenes, the GUI is what controls the camera, telling it when to expose, collecting its raw data, and stacking each frame into a final image. While this document serves as a full guide to how the software operates, it is hoped that all the relevant information for an observer is presented clearly to the user by this GUI.

1.3 TIPSI Specifications

Camera Core	FLIR Tau 2 Narrow Field of View
Array Size	640 x 512
Pixel size	17 microns
FOV	9.1’ x 7.3’
Resolution	0.8521”/pixel
Operating temperature	-40°C – +80°C (uncooled)
BLT primary mirror	0.51m
Focal Length	4115mm
F-number	f/8.1

1.4 Software Flowchart



2 Quick Start

This process is to launch the GUI and configure the camera with default settings. Then to take 5 images of an object named “Testing”.

1. Double click the application on the desktop “TIPSI_Control”

2. Navigate to the Configure panel
    a. Unlock by clicking the Unlock button once
    b. Chose the directory path to save to by clicking the Directory button
        i. A new window will open with a prompt to save to a folder
    c. Check to see in the Parameters panel if the Path has been set
    d. Check the Update Image checkbox
    e. Click the Initialize button once

3. Navigate to the Parameters panel
    a. Verify that the camera is connected and the settings are correct
        i. Camera Status = Connected!
        ii. Camera Model = FLIR Tau 2
        iii. Adapter = fleximaq
        iv. Format = Mono16
        v. Port ID = 1
        vi. Frames/Stack = 30
        vii. Raw Files = Saving
        viii. Data Reduce = Med Sub/Med Comb
        ix. Path = correct directory you chose
        x. Next Image (in UT date) = YYYYMMDD.00001.fits

4. Navigate to the Acquisition panel
    a. Enter in Object name “Testing”
    b. Enter “5” in # Of Image Stacks To Collect

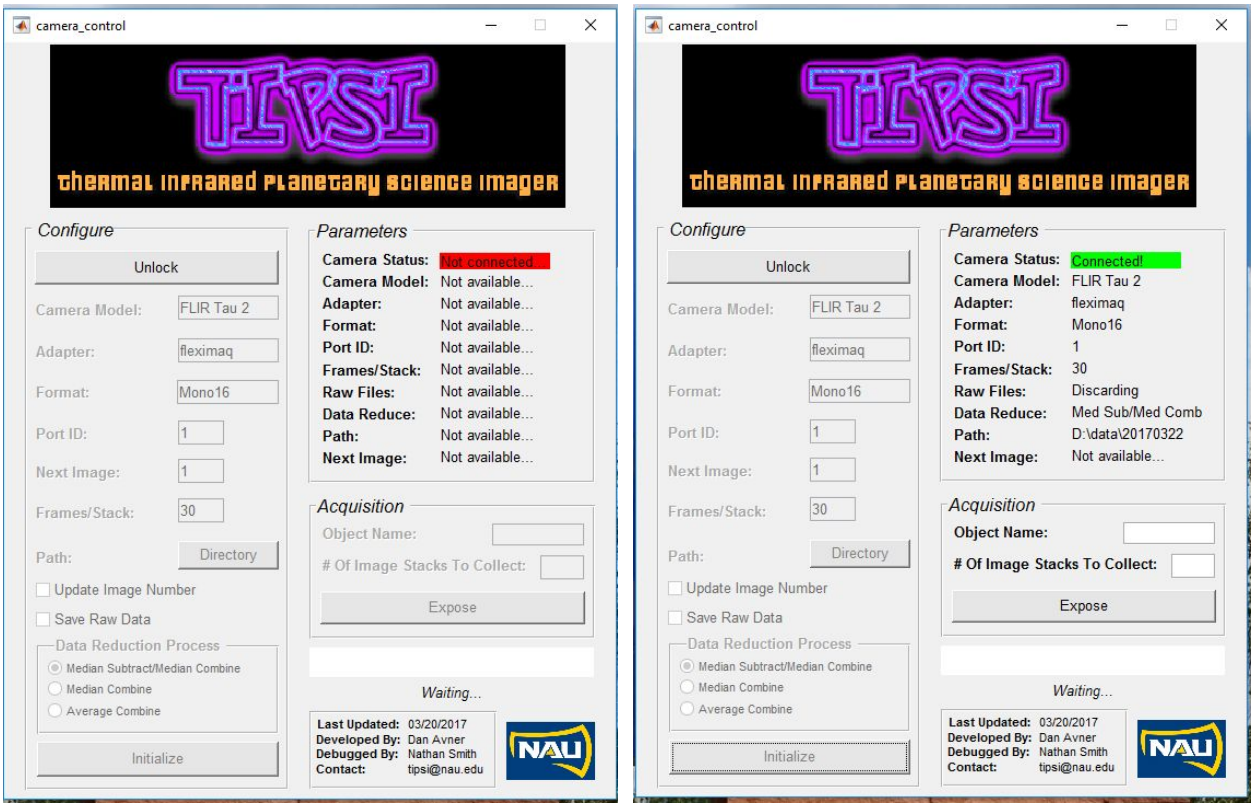
You have just successfully taken 5 image stacks by stacking 30 frames per image.

3 Panel Overview

3.1 Parameters

The Parameters panel in the GUI tells the user the settings that the camera and acquisition is set to. This should be used to verify the correct settings for image acquisition before starting exposures. These settings, excluding “Path”, will be updated upon the press of the Initialize button in the Configure panel. “Path” will update as soon as the user sets a path using the directory button in the Configure panel.

Upon creation of the GUI, “Not Available…” will be displayed for all parameters except for Camera Status, which will be red displaying “Not Connected…”.



After configuration and initialized the parameters will be updated with the current status. This is described in more detail below.

Camera Status

Displays the status of the thermal camera connection with either “Connected!” or “Not Connected…”. When the GUI is started, “Not Connected…” is displayed highlighted red. This does not mean that there is an error with talking to the camera but rather the camera has not been configured and initialized. After being correctly configured and initialized the status will be updated with “Corrected!” highlighted green.

Camera Model

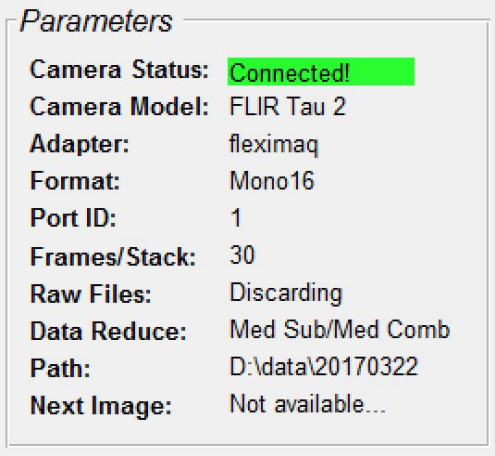
Displays the input from the user of the camera model. It is set to the default of Flir Tau 2. This is updated upon the press of the Initialize button in the Configure panel.

Adapter

Matlab Image Acquisition uses an adapter to communicate with the frame grabber. A Imperx frame grabber is currently installed and the adapter Imperx supplies is called “fleximaq”. This should not be changed unless a new frame grabber is installed. This is updated upon the press of the Initialize button in the Configure panel.

Format

The format that the video feed is acquired. Default is set to Mono16 and should not be changed. This is updated upon the press of the Initialize button in the Configure panel.



Raw Files

If the user has checked “Save Raw Data” in the Configure panel and Initialized, this will display “Saving”. If not, the status will display “Not Saving”.

Data Reduce

This parameter displays the type of data reduction that the user has specified in the “Data Reduction Process” in the Configure panel. This could display “Med Sub/Med Comb”, “Med Combine” or “Average Combine”. The default value is “Med Sub/Med Comb”.

Path

Path is the only parameter that is updated immediately the user specifies where to save the images and raw data (if that option is selected). This is for the user to confirm an accurate location to save the data.

Next Image

This gives a real time status of the next image to expose and write to the path. It does not display the current image. It will always be one image ahead of the current image.

3.2 Configure

The Configure panel is where the user needs to start to connect and initialize the camera. The user must unlock the panel by pressing the “Unlock” button. This allows the user to enter and change any settings. Currently, the “Camera Model”, “Adapter”, and “Format” are not available to the user to change.

Unlock/Lock Button

Unlocks the Configure panel for the user to modify. This is to prevent accidental modification. Changes are not saved until the Initialized button is pressed.

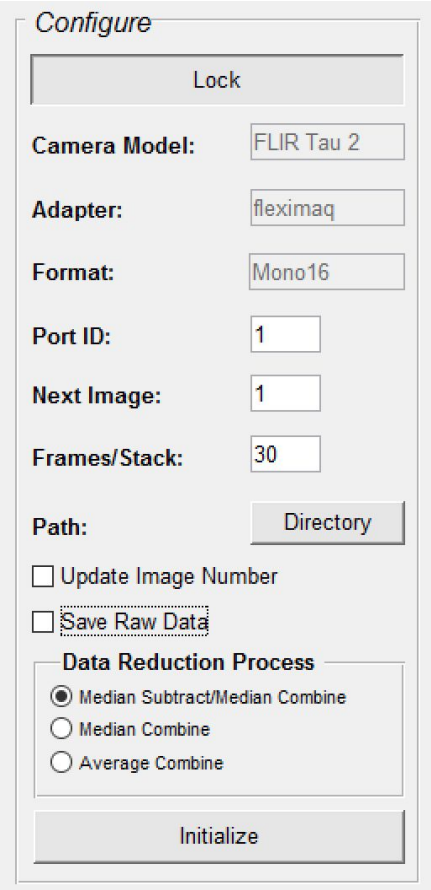
Camera Model
Disabled. Default is “FLIR Tau 2”

Adapter
Disabled. Default is “fleximaq”

Format
Disabled. Default is “Mono16”

Port ID
Allows the user to enter what port the camera is connected to. The default is “1”. For the Imperx frame grabber installed, there are 2 ports available, port 1 and port 2.

Next Image
The user can specify what image number for the next exposure to be written to. The default is “1” and the user must enter a positive nonzero integer along with checking the checkbox “Update Image Number”. This is to prevent the user from unknowingly updating the image number. The user only needs to enter the value. Do not enter leading zeros. It will be automatically formatted to YYYYMMDD.00000.fits where the date is the UT date and the value will have padded zeros until 5 characters long.



Frames/Stack
Here the user can tell how many frames to stack to make one image. The default is 30 frames which is 1 second of data collection. This must be a positive nonzero integer. For example, if the user wants to stack 10 seconds then they should enter 300 frames per stack.

Path (Directory)
When the user presses the “Directory” button, a window will be open where they must select where to save the data. The user should write the data to the “D:\” drive and in this window they have the ability to create the folder to write to.

Update Image Number Checkbox
When this checkbox is checked, the “Next Image” setting in the Parameter panel is updated to the image number supplied in the “Next Image” in the Configure panel. The default value of the checkbox is unchecked. The user can overwrite past fits files.

Save Raw Data Checkbox
The user has the option to save the raw frames before any sort of reduction process happens and the stack. When the user checks this box, the software knows to write the raw frames as fits files in the directory supplied in separate folders for every image stack. For example, if enabled and on image 20170327.00001.fits with a frame/stack of 90 images and collecting 2 image stacks, a folder in the directory is created called “00001”. In this folder resides raw.00001.fits, raw.00002.fits, …raw.00090.fits.

Then when the stacking for image stack 2, a folder is created in the directory called “00002” with the same amount of raw fits files.

Data Reduction Process

Median Subtract/Median Combine

The default data reduction process. When selected, this takes every individual frame and subtracts the median value of the array from every pixel value. Then these median subtracted frames are median combined into one single image stack. This lowers the total noise of the background while keeping the signal the same. This is the final fits file of the process.

Median Combine

When selected, the camera acquires all frames per stack then median combines them into one final fits file.

Average Combine

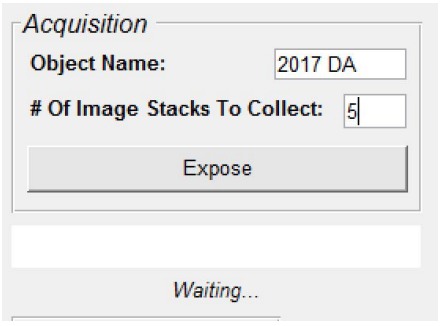
This data reduction process has the camera acquire all frames per stack then average them together into one final fits file.

Initialize Button

When pressed, the settings in the Parameters panel are updated. If not pressed and the Unlock/Lock button is pressed, the changes are not saved. The user is not able to initialize during exposures.

3.3 Acquisition

The Acquisition panel is where the user enters in an object name to be written as a header in the raw and final fits files as well as to tell the camera how many image stacks to collect. After, the user pushes the “Expose” button to start collecting data. The acquisition panel is not available to be modified until the camera is successfully configured and initialized.



Object Name

The user can add a name to the object to be written to a “OBJECT” header to the fits file for reference. This name will also be written to the raw fits files if the option to save the raw data is true. If nothing is entered the object name is “N/A”.

 # Of Image Stacks To Collect

The amount of image stacks to write. This needs to be a positive nonzero integer. If the user wants to collect 1 image with 60 frames per stack then the camera exposes for 2 seconds (30 frames a second) then with whatever data reduction process stacks those 60 frames into 1 image stack fits file.

Expose Button

When pressed, the process of collected frames from the camera and reduced with the data reduction process specified begins. A progress bar below the button begins. When the exposure is finished for the amount of image stacks to collect and written as fits files, the progress bar turns green. When green, the camera is ready to expose again.

4 Data Reduction Overview

This section details the data reduction done by the TIPSI GUI when generating a stacked image. The processing performed depends on the data reduction process selected in the *Configure* panel, detailed above in section 3.2. The default setting is *Median Subtract, Median Combine*.

4.1 Median Subtract, Median Combine

This is the default data reduction process. It is intended to be used when observing objects which do not fill a significant portion of the field of view, such as stars, planets, asteroids, and comets.

First, the process performs a median subtract on every frame captured: it takes each individual frame and subtracts that frame's median pixel value from every pixel in that frame. This is intended to remove the background offset produced by the sky, *i.e.*, the atmosphere's own thermal IR emission around 10 microns.

Next, these median subtracted frames are then median combined into one single image stack. Each individual frame only contains a few counts of signal from the object being observed. The remainder of the counts are noise, produced by the detector, the sky, and all other sources. The median combination calculates and records the median value of some pixel across all of the frames captured. In this way, the random variation from one frame to the next is smoothed out. The noise of the background is thus reduced below the signal, revealing the object. This stacked image, is then recorded as the final output FITS file for the observation.

4.2 Median Combine

This setting performs only the second portion of the reduction process detailed in section 4.1. It is intended for use when observing an object which fills the whole field of view of the detector, *i.e.*, the Moon. In this case, the median value of each captured frame would not accurately represent the sky background, as signal from the object would be arriving at every pixel in the field of view. Thus it becomes necessary to forego removing the sky background, and instead only stack the collected frames into a final stacked image. Once again, this is done to reduce the noise which produces frame-to-frame variation of each pixel.

When using this mode, it may be important for the observer to determine the true signal of the Moon--that is, the signal not due to the thermal emission of the sky. In that case, we propose periodically sampling the sky contribution by capturing a nearby field of "empty" sky: slew the telescope away from the Moon, and (using the Median Combine data reduction mode) expose on a field with no thermal-IR sources. Later on, the median value of this sky-field can be subtracted from each stacked science image. With a number of these sky-fields collected throughout the observing period, it will be possible to reconstruct how the average sky contribution varied throughout the night.

4.3 Average Combine

This setting is comparable to the *Median Combine* setting detailed in section 4.2, except it uses the simple mean rather than the median to stack the images. It is implemented as a test, to observe the differences between the two. It is expected that the mean will include the effects of more artifacts, such as cosmic rays, which the median will largely ignore.

5 Examples

Below are some examples of how to operate the camera using the GUI. The first example shows how to start from the beginning of the run and how to initialize the camera. The second example of more of changing targets, overwriting images, and changing data reduction process.

5.1 Observing Run 1

This is the first run of the night and the camera must be configured and initialized. You want to observe asteroid 2017 DAN. You want to collect 30 frames per image stack and acquire 60 image stacks and save the raw data. You also want to reduce the data by subtracting the median followed by median combining. You then want to look at the the last image and see if anything needs to change. You then decide it is ok and take 300 more image stacks with the same frames per stack. Then you decide to leave for the night.

1. Double click the application on the desktop called “TIPSI_Controller”

2. Navigate to the Configure panel
    a. Click the Unlock button once
    b. Verify that the camera model, adapter, format and port are correct
        i. If not notify tipsi@nau.edu
    c. Make sure the “Next Image” = 1
    d. We want 30 frames/stack so verify “30” is entered in the “Frames/Stack” box
    e. Click once the Directory button for Path
        i. This opens a new window to select which folder to write
        ii. Navigate to folder “data”
        iii. Make a new folder of the current UT date
            1. 20170327 for March 27th, 2017
        iv. Select folder to save data to
        v. Verify in the Parameters panel that the path has correctly changed
    f. Check the “Update Image Number” checkbox
    g. Verify the “Save Raw Data” checkbox is True
    h. Navigate to the Data Reduction Process panel in Configure panel
        i. Verify that the radio button for Median Subtract/Median Combine is selected
    i. Press the Initialize button once

3. Navigate to the Parameters panel
    a. Verify that you have a green “Connected!” for Camera Status
    b. Verify that the parameters are correct
    c. Verify that Next Image shows the UT date and image number of next fits file
        i. 20170327.00001.fits for March 27th, 2017

4. Navigate to the Acquisition panel
    a. Enter in Object Name “2017 DAN”
    b. Enter “60” in # Of Image Stacks To Collect
    c. Click the Expose button once

5. Verify that a progress bar has started filling below the Expose button

6. When the progress bar turns green, all 60 image stacks with 30 frames per stack are finished

7. Navigate to the directory specified to save and verify the files are there
    a. Double click a file to open it in a fits file viewer, DS9
    b. Enter that files subfile and verify that 30 raw fits files are there

8. Navigate to the Acquisition panel
    a. Change the # Of Image Stacks To Collect to “300”
    b. Click once the Expose button
    c. A progress bar below the Expose button should start filling

9. To shut down the camera, simple close the application after exposing is finished by clicking the small red “X” in the top right corner

5.2 Observing Run 2

You want to observe the moon halfway through an observing run starting after taking 300 images of an asteroid leaving the next image being YYYYMMDD.00301.fits. You want 15 frames per stack and do not want to save the raw data. You want to use the average combine data reduction process. You take 100 image stacks. You realize something was wrong for all of the images and want to overwrite them and take 100 image stacks again but with Median Combine data reduction process this time.

1. Navigate to the Configure panel
    a. Click the Unlock button once
    b. Verify that the camera model, adapter, format and port are correct
        i. If not notify tipsi@nau.edu
    c. We want 15 frames/stack so verify “15” is entered in the “Frames/Stack” box
    d. Verify the “Update Image Number” checkbox is False
    e. Verify the “Save Raw Data” checkbox is False
    f. Navigate to the Data Reduction Process panel in Configure panel
        i. Verify that the radio button for Average Combine is selected
    g. Press the Initialize button once

2. Navigate to the Parameters panel
    a. Verify that the parameters have updated
        i. Frames/Stack = 15
        ii. Data Reduce = Average Combine
        iii. Next Image is still the same

3. Navigate to the Acquisition panel
    a. Enter in Object Name “Moon1”
    b. Enter “100” in # Of Image Stacks To Collect
    c. Click the Expose button once

4. Verify that a progress bar has started filling below the Expose button

5. When the progress bar turns green, all 100 image stacks with 15 frames per stack are finished
    a. Next Image in parameters should read YYYYMMDD.00401.fits

6. Navigate to the directory specified to save and verify the files are there
    a. Double click a file to open it in a fits file viewer, DS9

7. Navigate to the Configure panel
    a. Click the Unlock button once
    b. Change the Next Image to “301” since we want to overwrite all we just took
    c. Check the “Update Image Number”
    d. Press the radio button for Median Combine
    e. Click the Initialize button once

8. Naviage to the Parameters panel
    a. Verify what you changed
        i. Data Reduce = Median Combine
        ii. Next Image = YYYYMMDD.00301.fits

9. Navigate to the Acquisition panel
    a. Click the Expose button

6 FAQ And Troubleshooting

Why is the Camera Status in the Parameters panel red?
This is because the camera has not been initialized yet.

Why can I not access the Acquisition panel?
Once the user successfully initializes the camera, the acquisition panel becomes available. Also the Acquisition panel is not available while exposing.

Why can I not access the Configure panel?
The user must “Unlock” the panel by pressing the Unlock button. Also, the Configure panel is not available while the camera is exposing.

I accidently closed the GUI while taking data, what are the consequences?
The GUI does a good job of controlling this however a fits file may be left “open”. This means you should just delete the last image it was on so that it doesn’t have an issue writing over it. The GUI cannot write over open fits files.

I accidently updated the image number to 1 when I am really at image 5782 (really any image), what should I do?
You can configure the parameters again and change the Next Image in the Configure panel to whatever image you left on. Make sure to initialize it after changing the Next Image for updates to take.

If the camera is not connecting and you are getting a warning message when you initialize please check:

- The port might be 2 instead of 1
- You put a decimal in any of the inputs (do not do that!)
- Something is wrong with the software and please email tipsi@nau.edu

If the progress bar does not turn green after collecting the image stacks check to see if it is actually done. If you are stacking 300 frames then each image will take 10 seconds.

If the progress bar stalls, there is an issue collecting data. Check to see if you have a fits file open that the camera is in process of writing. This will cause the software to crash.

When in doubt, make sure that none of your inputs include decimals, underscores, or just weird things. You are a physics student, be smart.

If you have any questions please email tipsi@nau.edu

7 Acknowledgements

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Special thanks to Ed Anderson for assisting with the design and installation of TIPSI.

8 Appendix

Configure Panel		
Description	**Input Type**	**Default Value**
Camera Model	String (Disabled)	“FLIR Tau 2”
Adapter	String (Disabled)	“fleximaq”
Format	String (Disabled)	“Mono16”
Port ID	String	“1”
Next Image	Positive Nonzero Integer	“1”
Frames/Stack	Positive Nonzero Integer	“30”
Path	Interactive Button	“D:\”
Update Image Number	Checkbox	Disabled
Save Raw Data	Checkbox	Enabled
Data Reduction Process	3 Radio Buttons	“Median Subtract/Median Combine”

Parameter Panel	
Description	**Possible Display**
Camera Status	“Not Connected…” “Connected!”
Camera Model	“Not Available…” “FLIR Tau 2”
Adapter	“Not Available…” “fleximaq”
Format	“Not Available…” “Mono16”
Port ID	“Not Available…” “1” “2”
Frames/Stack	“Not Available…” Any Positive Nonzero Integer
Raw Files	“Not Available…”

	“Saving” “Not Saving”
Data Reduce	“Not Available…” “Med Sub/Med Comb” “Med Combine” “Average Combine”
Path	“Not Available…” Any Path
Next Image	“Not Available…” Any Positive Nonzero Integer

Acquisition Panel		
Description	**Input Type**	**Example Inputs**
Object Name	String	“2015 KP” “Sirius” “Moon 1”
# OF Image Stacks To Collect	Positive Nonzero Integer	Any value